

Fish Community Patterns on 4 Receiving Waters 1998 - 2001

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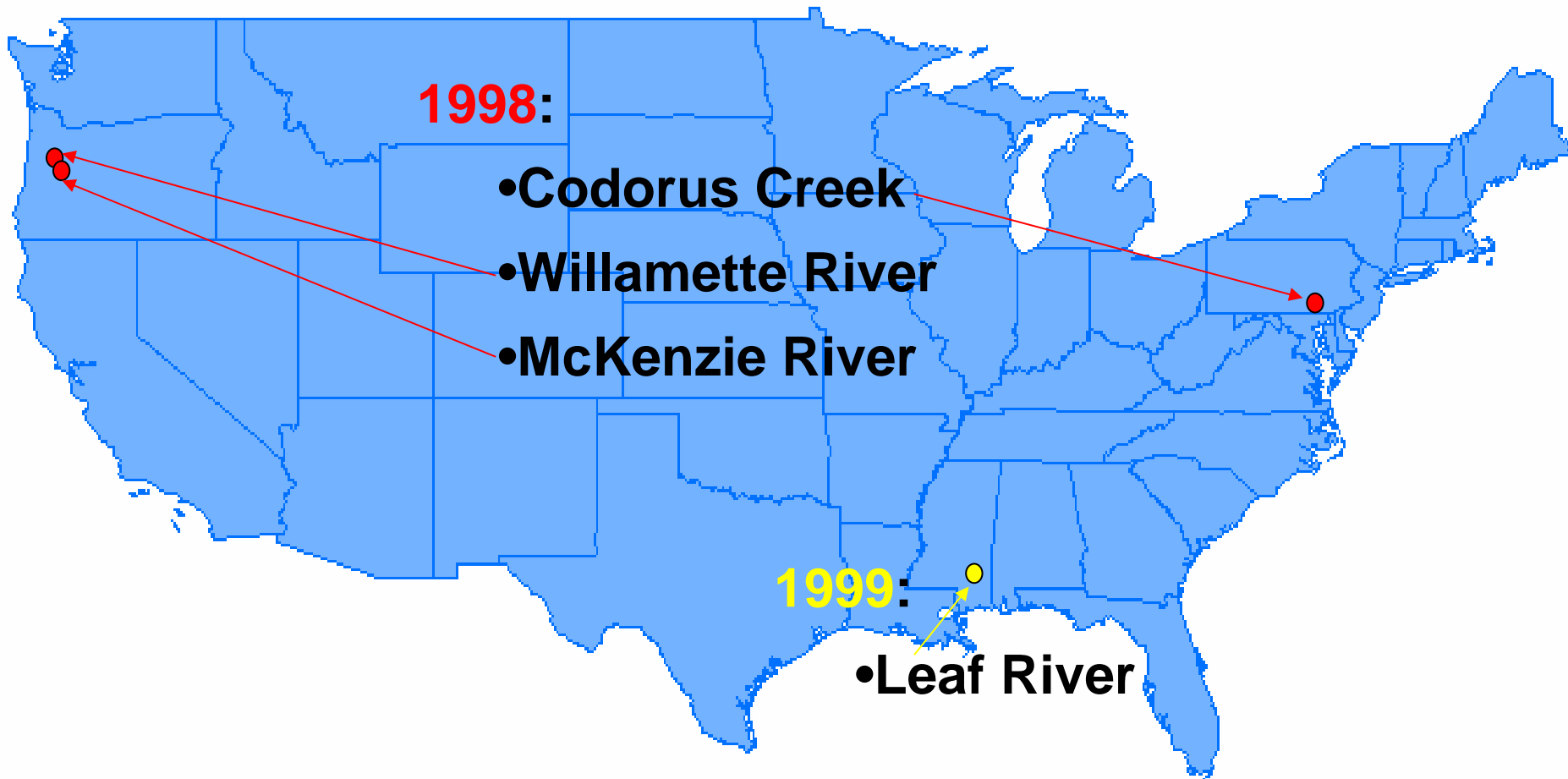
May 2004

Long-Term Receiving Water Study (LTRWS): Are there differences upstream/downstream of mill discharges?

- Instream monitoring
 - Fish
 - Macroinvertebrates
 - Algae
 - Water Quality
- Bioassay
- Mesocosm
- Fathead minnow life cycle tests



LTRWS Locations and Start-up Dates



Analytical Methods

- Multivariate Analysis

1. Raw assemblage data: what fish are where and how many?
2. Similarity Index (Bray-Curtis).
3. Ordination to see relative similarities between sites (MDS).
4. Permutation testing to test if sites are sig. different.
5. A forward/backward stepwise procedure to identify influential organisms.
6. Correlate the independent water quality variables with the fish patterns.

- Indices

1. Index of biotic integrity (IBI)
2. Diversity Indices (Shannon's H' and Simpson's $1-\lambda$) and evenness measurement (Pielou's J').

Willamette River:

Combined Bleached Kraft & unbleached recovered fiber
0.2% effluent at the edge of the mixing zone



Most abundant species:

- largescale sucker (40.7%)
- mountain whitefish (15.1%).

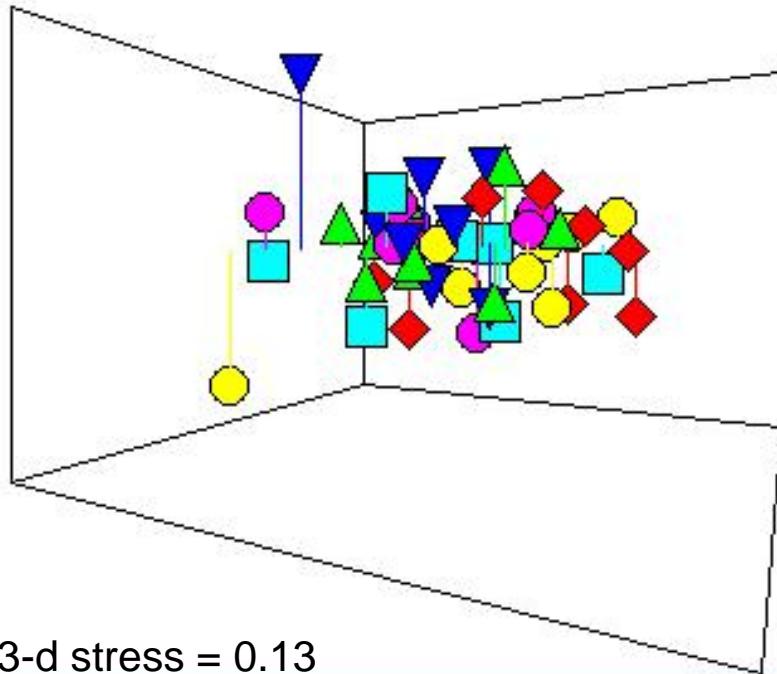
Boat electrofishing

- 8 Sampling dates:
 - 1998: Sept & Dec
 - 1999: Mar, Jun, & Sept
 - 2000: Mar, May, & Sept
- Total Catch = 2,474 fish in 31 taxa (28 species).



Willamette River: MDS

Willamette Boat Population: 3-Dimensional MDS



▲ -20.4KM

▼ -17.2KM

■ -0.9KM

◆ +3.7KM

● +10.2KM

● +22.0KM

- No visible relationship between sites (buckshot).

- No significant differences between sites.

Willamette River: Summary

- No pattern of site separation.
- No significant differences between sites.
- Some seasonal temporal variations were significant, no annual differences.
- IBIs found no significant differences between sites.
- Diversity and evenness measurements (Shannon's H' , Simpson's $1-\lambda$ and Pielou's J') found no significant differences between sites.

No significant difference upstream/downstream in the fish communities on the Willamette.

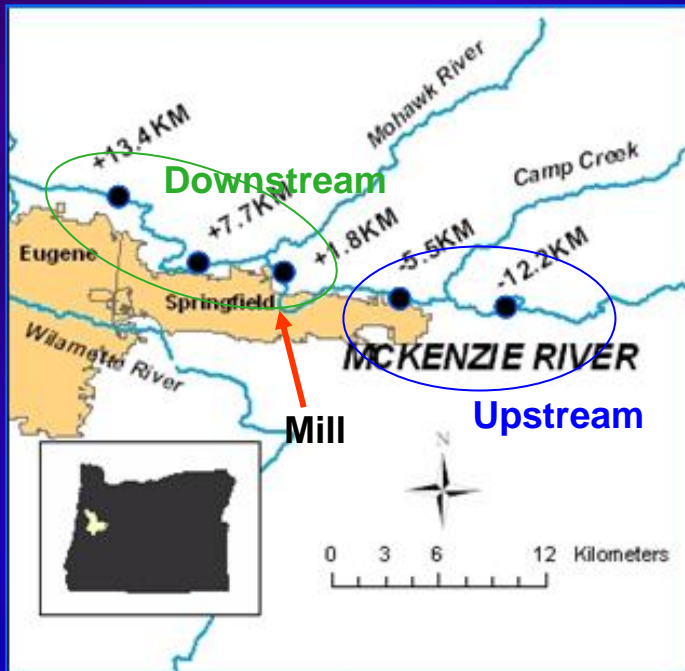
McKenzie River:

Unbleached kraft mill

0.6% Effluent at the edge of the mixing zone

Boat Electrofishing

- 8 Sampling dates:
 - 1998: Sept & Dec
 - 1999: Mar, Jun, & Sept
 - 2000: Mar, May, & Sept
- Total Catch = 1,720 fish in 22 taxa (17 species).

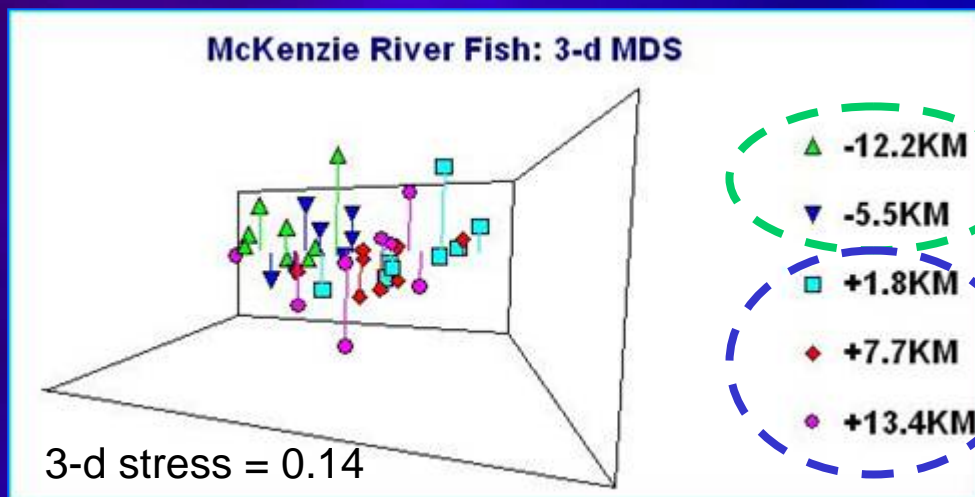


Most abundant species:

- cutthroat trout (28.1%)
- largescale sucker (21.4%).



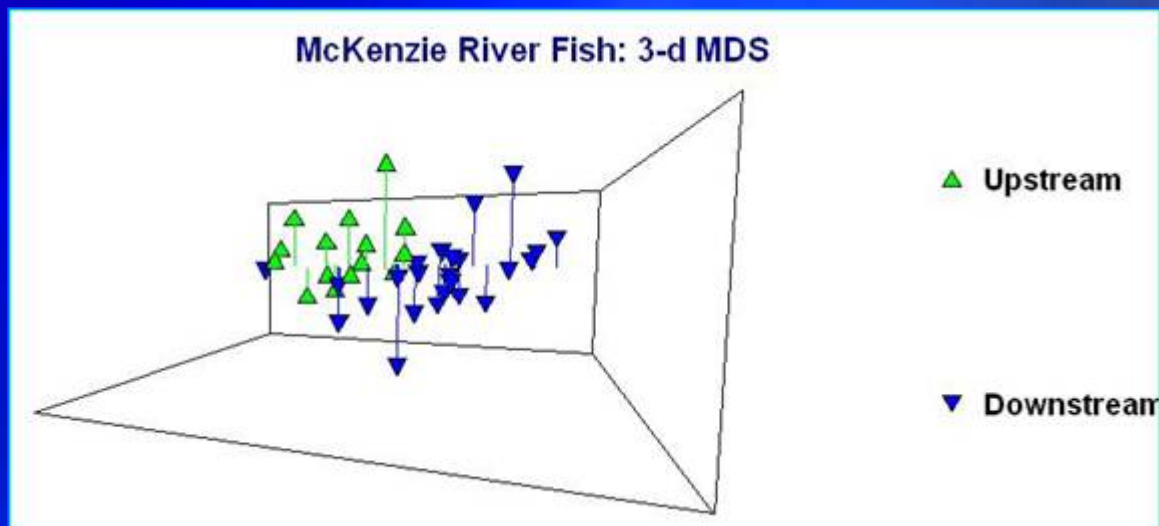
McKenzie River: Multivariate Analysis



- No significant differences

- Relabel to upstream-downstream:

- The “upstream” sites are significantly different from the “downstream” sites.



McKenzie River: Influential Species

- 8 out of 22 taxa contributed 95.1% of the community pattern.

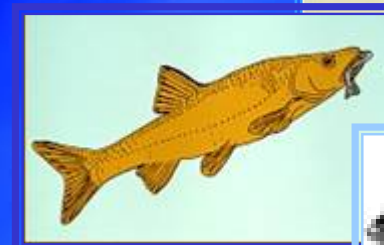
- Salmonids:

- Cutthroat trout,
- mountain whitefish,
- wild and hatchery rainbow trout, and
- chinook salmon.

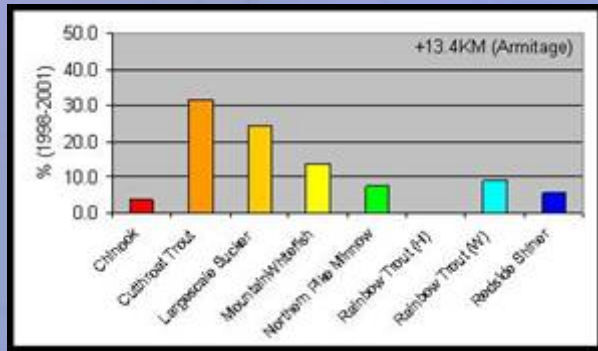
- Other:

- largescale sucker,
- northern pikeminnow and
- redbreast shiner.

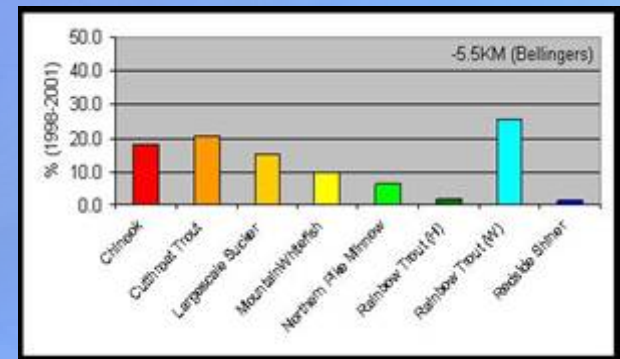
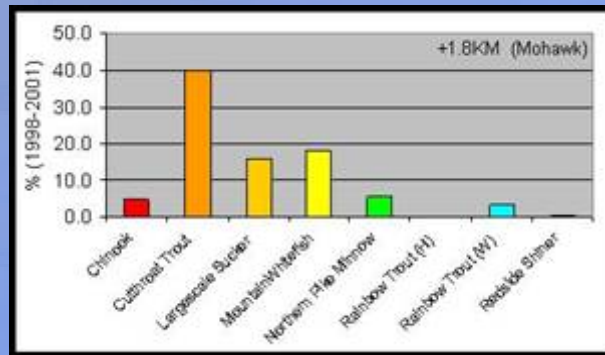
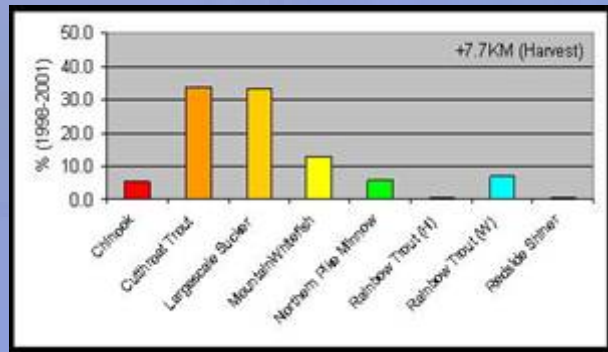
- These 8 taxa made up 95% of the total catch.



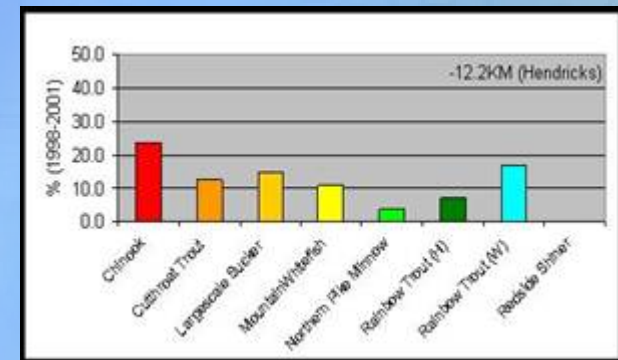
McKenzie River: Distribution of Influential Fish Species



Downstream



Upstream



Effluent
Discharge



McKenzie River: Water Quality Analysis

- Variables fell into 3 correlated groups:
 1. Conductivity, TDS and Hardness.
 2. pH, Temperature and Total Nitrogen (TN).
 3. Color, Turbidity and TN.
- pH, Temperature and TN correlated 48.7% with the fish pattern.

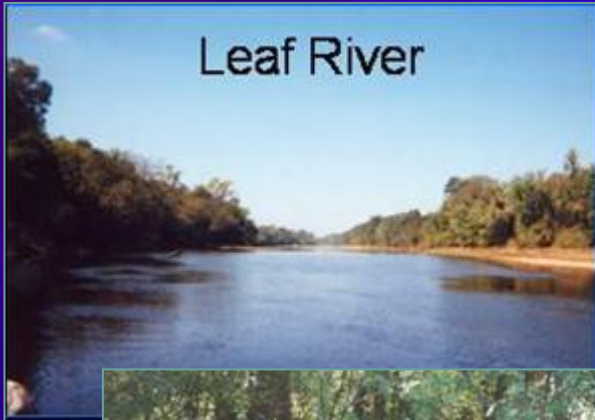
McKenzie River: Summary

- The “upstream” sites are significantly different from the “downstream” sites.
- 8 species contributed 95.1% of the fish pattern (and comprised 95% of the catch).
- 3 water quality variables (pH, temperature and TN) correlated 48.7% with the fish pattern.
- Some seasonal temporal variations were significant; no annual differences.
- IBIs, diversity and evenness measurements found almost no significant differences between sites.

Upstream-Downstream break in fish communities correlated with non-effluent specific water components, what else is driving this pattern?

Leaf River:

- Bleached Kraft Mill
- Effluent 4.0% at edge of mixing zone



- Sampling dates:

- Boat 2 dates: October, 1999 & 2000
- Backpack 1 date: October 2000

- Total Catch = 3,244 fish:

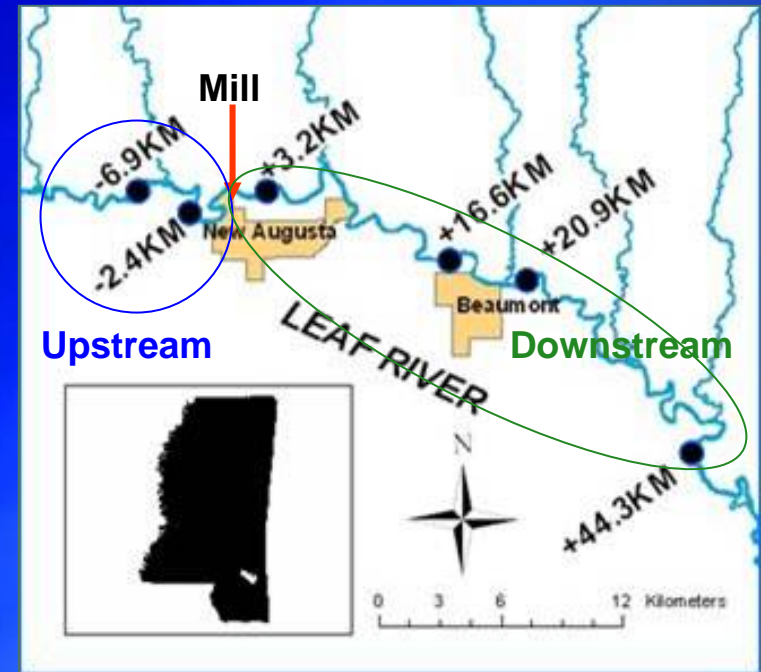
- 2,050 fish in 37 species with boat;
- 1,194 fish in 19 species with backpack equipment.

- Most abundant Boat species:

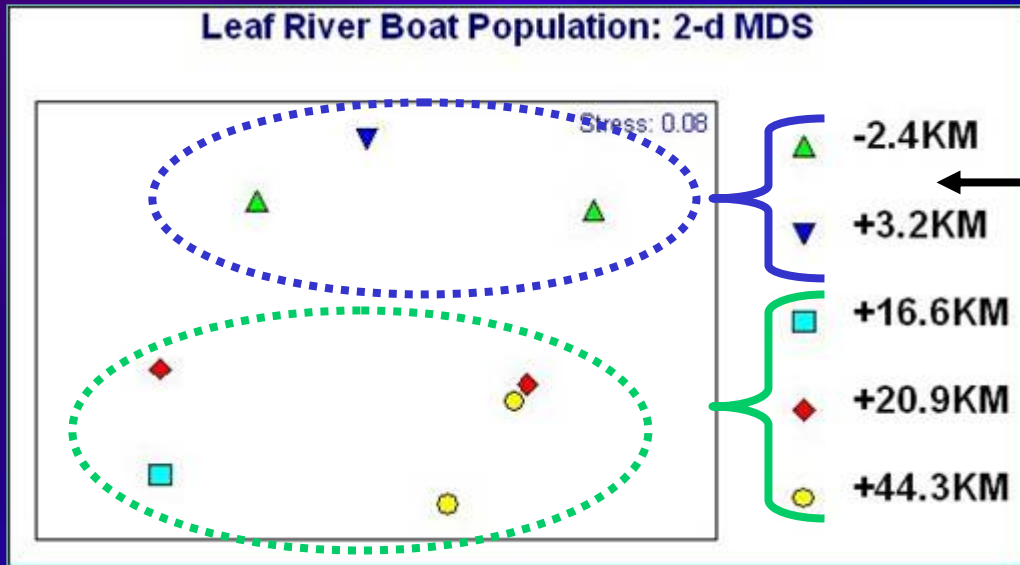
- longear sunfish (17.4%)
- blacktail shiner (12.6%).

- Most abundant Backpack species:

- blacktail shiner (53.7%)
- longnose shiner (19.4%).

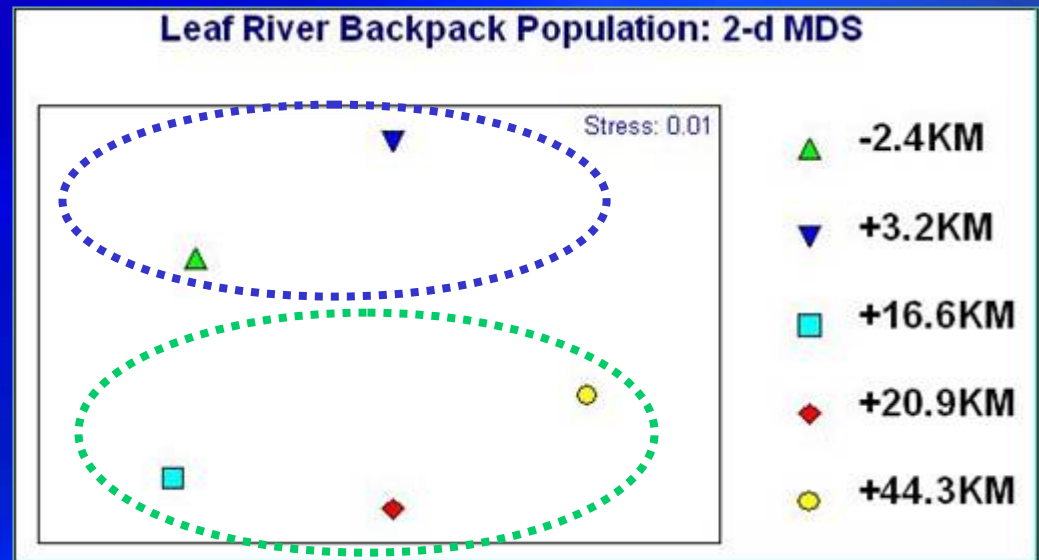


Leaf River: Multivariate Analysis



Mill Effluent
Discharge

- Visual separation between upstream sites and downstream sites for boat and backpack populations.
- Pattern is not stat. significant.
- Possibly due to low sample number, missing data and the large annual variation.



Leaf River: Summary

- No significant fish community patterns for boat or backpack collected populations.
- Significant and sizeable annual variation.
- Diversity and evenness measurements found no significant differences between sites.

1) No significant differences found in fish communities.

2) A possible upstream-downstream break was identified that was not geographically associated with the effluent discharge.

3) More time and data will tell the story.

Codorus Creek:

- Bleached Kraft Mill
- 38% at edge of mixing zone

12 Sampling dates:

- 9/98, 11/98
- 3/99, 6/99, 9/99, 11/99
- 3/00, 6/00, 9/00, 11/00
- 3/01, 6/01

Codorus
Creek

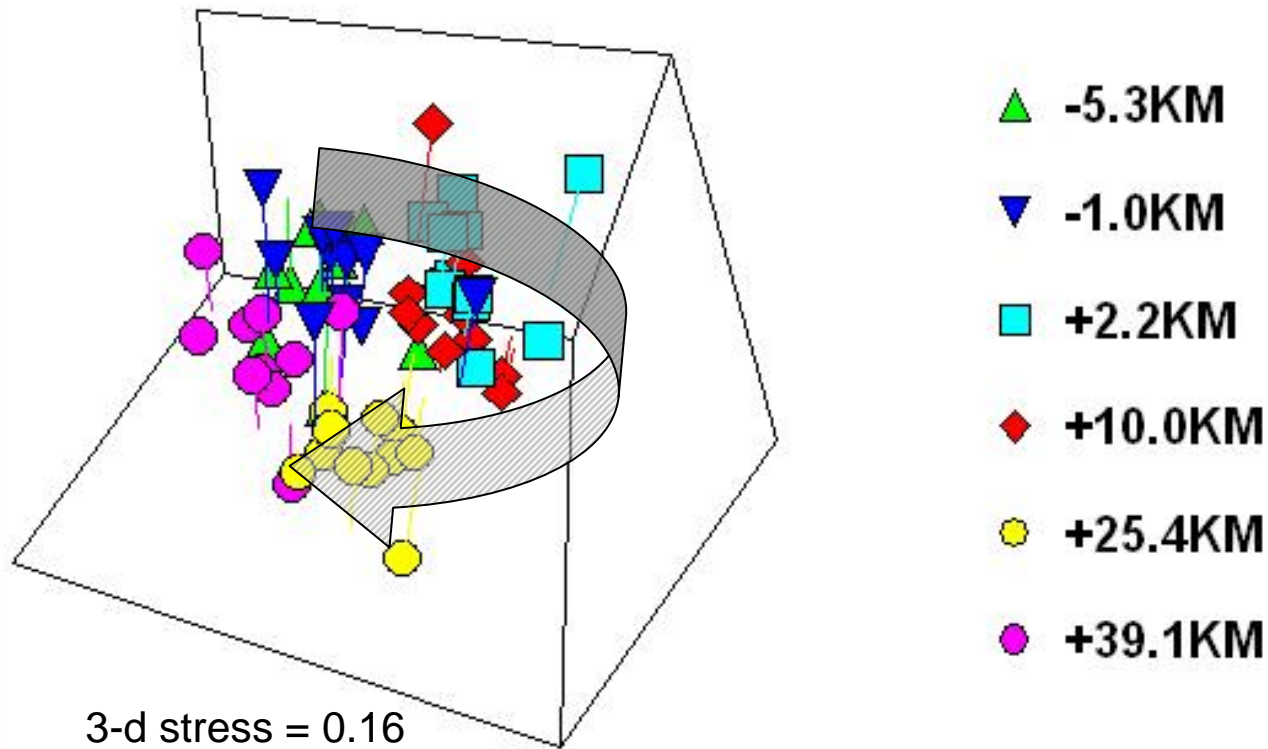


- Total catch = 5,762 fish in 44 taxa (38 species).
- Most abundant species:
 - green sunfish (16.2%)
 - spottail shiner (11.1%)
 - Cyprinidae (9.0%)
 - swallowtail shiner (8.7%)
 - redbreast sunfish (8.4%).



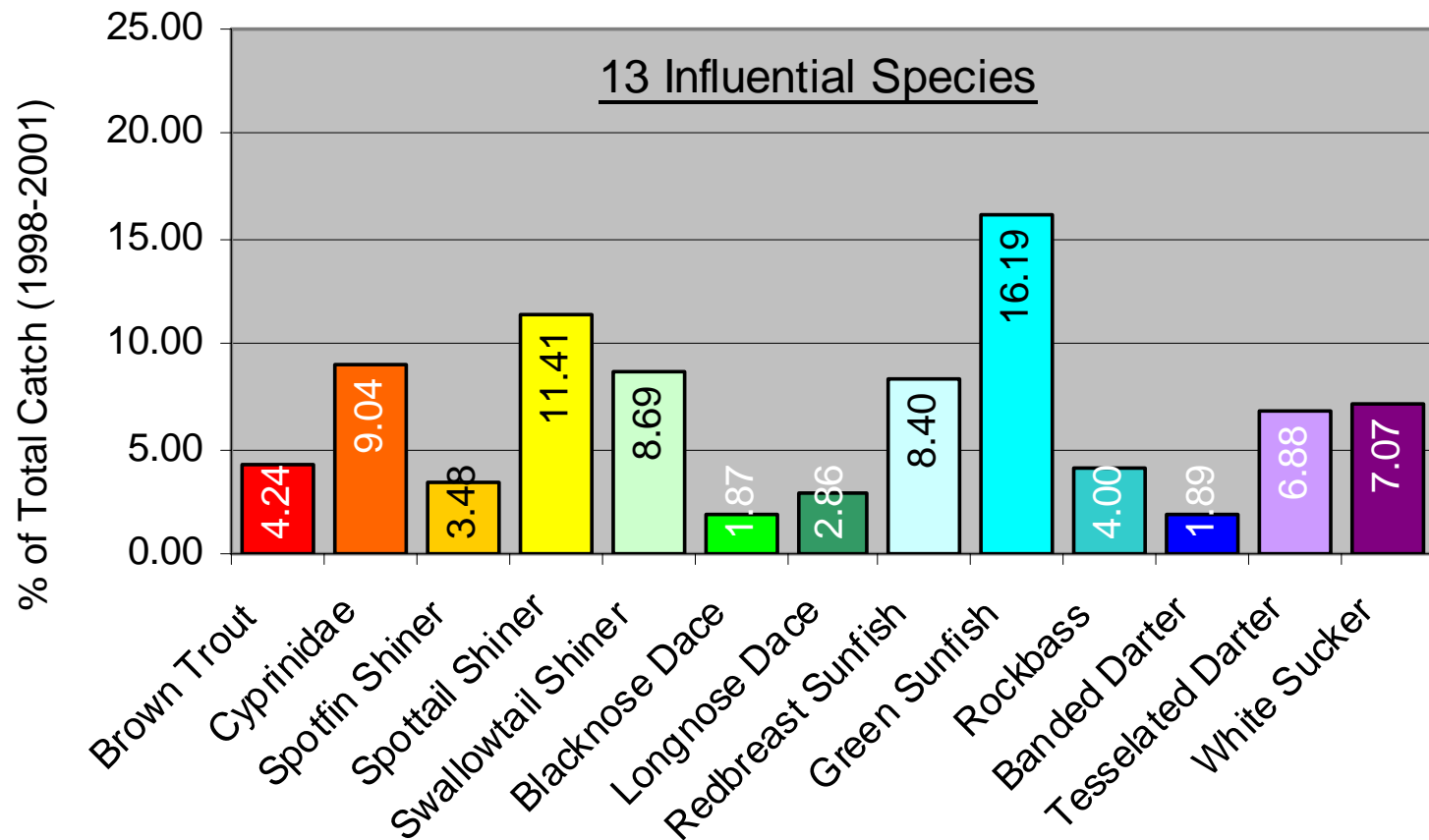
Codorus Creek: Multivariate Analysis

Codorus Creek Fish: 3-d MDS



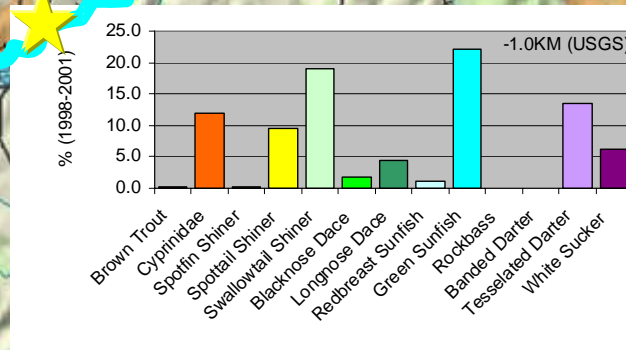
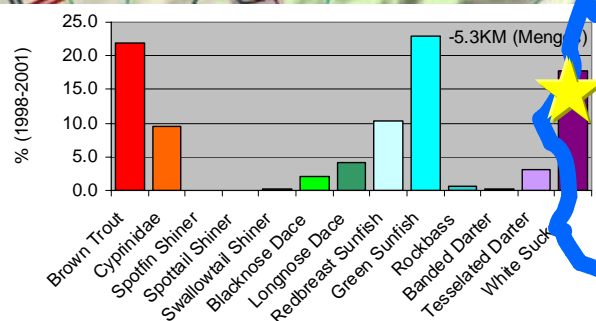
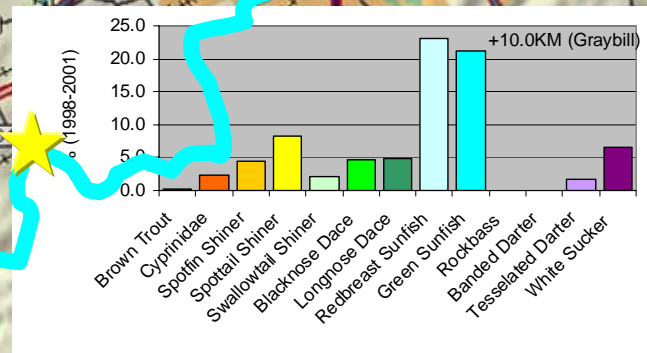
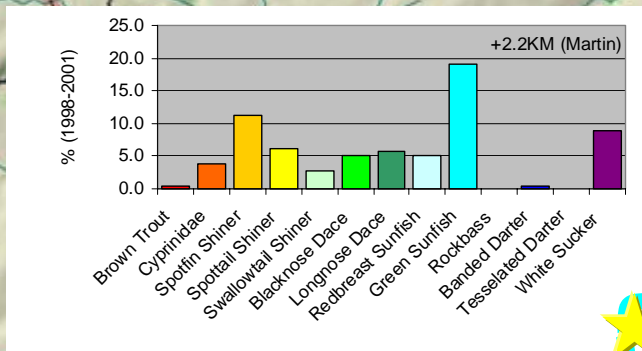
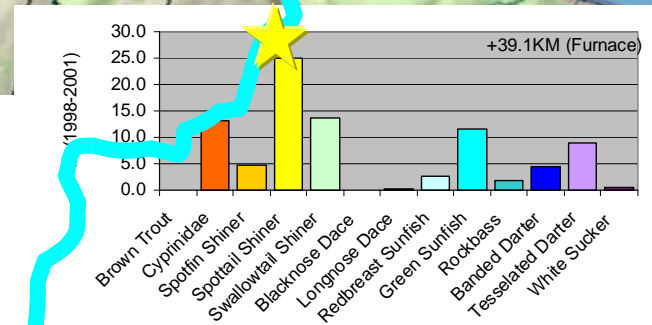
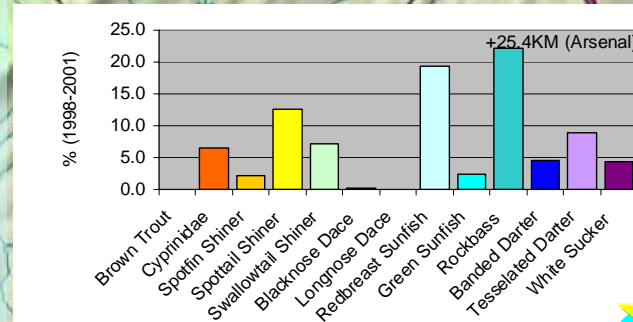
Codorus Creek: Influential Taxa

- 13 out of 44 taxa contributed 95.4% of the pattern (& 86% of the catch)



Codorus Creek:

Distribution of Influential Species





Codorus Creek: Water Quality Correlation to Fish Community Pattern

- 3 water quality variables correlated 29.2%: temperature, TP, and TN
- Individual variables:
 - Conductivity 21.9%
 - Temperature 21.4%

Codorus Creek: Summary

- Upstream/downstream gradient with all sites significantly different.
- 13 species contributed 95.4% of the fish pattern.
- 3 water quality variables (temperature, TP, and TN) correlated weakly (29.2%) with the fish pattern.
- Conductivity (considered a mill effluent marker) and temperature had 2 highest individual correlations with the fish community pattern (21.9% and 21.4%, respectively).
- IBIs, evenness and diversity indices identified the coldwater site. IBIs also differentiated the mainstem sites from the West Branch

Effluent dominated (38%) stream had a gradient in fish communities weakly (<22%) associated with effluent marker.

4 River Summary

1. Found a pattern of relative magnitude of response:
 - From the small effluent dominated receiving water with a significant fish community gradient weakly associated with effluent markers,
 - to the larger more typical receiving waters with small to nondetectable fish community gradients associated with effluent marginally or not at all.
2. Traditional measurements of impact (evenness or diversity measurements; IBIs) showed no gradients on any of the rivers, and on the effluent dominated river were only able to identify the coldwater site or stream order.

Where to next?

Highest correlation with WQ was still less than 50%...

- Further partitioning:
 - will allow a more definitive statement of how much of the pattern is a natural gradient, how much mill effluent driven and how much alternate stressor driven.
 - Habitat analysis
 - Nutrient analysis
 - Fish external health evaluation data analysis.

The Willamette River, near Corvallis

